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Organization: Michigan State University

Review #5

Proposal Number: 0941492
Performing Organization: Michigan State University
NSF Program: CCLI-Type 1 (Exploratory)
Principal Investigator: Sibley, Duncan
Proposal Title: Collaborative Research: Building Global Climate Change Literacy through Analogical Reasoning
Rating: Very Good

REVIEW:

What is the intellectual merit of the proposed activity?

There are broad implications for understanding how students understand complex ideas related to climate change. An important element of advancing higher order thinking and analysis lies in determining the misconceptions that students have regarding the scientific content and when they occur in the learning process. The project could have significant implications for increasing public scientific literacy, though there is great need to design a plan for affective implementation of analogical reasoning (i.e. faculty development). The project will be implemented in (and is designed for) an undergraduate course of non-majors courses which typically have more underrepresented groups than most courses for science majors at our university. Because the project is actually designed to better understand cognition and the development of complex concepts around scientific facts, there will be broad impact beyond the undergraduate curriculum. The materials will also be useful for K-12 teachers and educators in informal settings who want to help the public understand the science behind issues of global change, as well as for science majors who must learn to communicate through both scientific analogies and models".

What are the broader impacts of the proposed activity?

The authors provide an interesting and insightful discussion of the importance and relevance of analogical reasoning in STEM (Geoscience) education. The intellectual merit of the project is derived from the potential discovery regarding cognition and metacognition, specifically at what point in the learning process do students (people in general) develop misconceptions that inhibit scientific literacy (e.g. retrieval). The proposer is an expert in the study of analogical reasoning and has experimented with implementation of analogical reasoning at the undergraduate level with limited success. Previous work appeared to be limited by the plan for assessment. The proposal will produce innovative materials "analogical reasoning exercises and data on student responses on the GCI website". In addition the project will help provide important finding to advance our understanding of STEM education, producing a model of how to teach analogical reasoning and perhaps improving students' ability to reason about global climate change. The specific activities related to STEM education are to 1) create of a series of analogical reasoning exercises; 2) develop formative and summative assessments of analogical reasoning; and 3) determine of the extent to which students increase their ability to map, evaluate and retrieve analogies in relation to global climate change. The objectiveness of the project design is questionable as it utilizes Sibley as the single instructor for both a

control and experimental group of undergraduates in an introductory geoscience course. In addition the evaluation and assessment process relies almost completely on the development of the software - SPSS Text Analysis for Survey's which was created in a previous project and will be applied in this study. While innovative it would seem reasonable for the proposers to provide information on how the SPSS results are integrated in to curriculum redesign.

Summary Statement

The project is designed to develop new instructional materials and assessment instruments based on cognitive scientists' understanding of analogical reasoning. There is intellectual merit that stems from a better understanding of how students use analogical reasoning to understand complex concepts around climate change. The authors have outlined a detailed understanding of the processes involved in analogical reasoning in order to better understand how and when students develop misconceptions in the learning process. The results will have broad impacts on STEM education if the proposers develop their dissemination plan to focus on faculty education. Adding a third years of funding which includes evaluation of the faculty response to this approach and the results of implementation beyond the classroom of Dr. Sibley would be worthwhile.

The project would be more likely to be funded if the reviewers added a incorporated faculty workshops and a dissemination plan for faculty development around the integration of analogical reasoning. Still the requested budget is modest and designed to support a graduate student, which is in itself an opportunity to advance STEM education. A thorough discussion of the value of SPSS an analytical tool and its necessity is warranted in the final evaluation.

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Organization: Michigan State University

Review #4

Proposal Number: 0941492
Performing Organization: Michigan State University
NSF Program: CCLI-Type 1 (Exploratory)
Principal Investigator: Sibley, Duncan
Proposal Title: Collaborative Research: Building Global Climate Change Literacy through Analogical Reasoning
Rating: Excellent

REVIEW:

What is the intellectual merit of the proposed activity?

This proposal is very strong. It meets most of the NSF & CCLI suggested criteria for Intellectual Merit. The approach proposed, using analogy-based instruction & the development of analogy-based curricula on climate change as a means to demonstrate scientific reasoning is innovative and built upon previous science education research. All investigators are experts in the proposed areas of research and have solid track records in previous research programs. The curricula and assessment instruments that will produced from this project have the potential for wide utility across many STEM disciplines. This project has explicit and well-thought out objectives that are well-integrated into a strong and objective evaluation plan.

Hard to find weaknesses from my perspective. Can't wait for the products!

What are the broader impacts of the proposed activity?

Products produced & strategies developed from this project will enhance STEM learning as well as scientific literacy about climate change by facilitating practice of scientific reasoning by a diverse population of non-science major students.

Standard meeting presentations, journal article pubs & website dissemination is planned. Pis have solid track record with respect to such dissemination. Seems like this really creative bunch could come up with more creative and innovative approach to dissemination. Just a thought.

Summary Statement

This is a very strong proposal with a well conceived and organized project plan, explicit measurable outcomes, hypotheses to test and questions that they hope to answer and a solid evaluation plan. An excellent example of a Type 1 CCLI proposal. I highly recommend this proposal for funding and anxiously await what they produce.

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Organization: Michigan State University

Review #3

Proposal Number: 0941492
Performing Organization: Michigan State University
NSF Program: CCLI-Type 1 (Exploratory)
Principal Investigator: Sibley, Duncan
Proposal Title: Collaborative Research: Building Global Climate Change Literacy through Analogical Reasoning
Rating: Very Good

REVIEW:

What is the intellectual merit of the proposed activity?

The PIs constitute a team of experts in the areas of cognition, geoscience conceptualization, and geoscience instruction. Their goals are to improve the understanding of climate science concepts to foster better understanding of global change processes and impacts. They note correctly that the average person has little knowledge of why climate scientists consider anthropogenic releases of CO₂ to be leading to climate change. Rather, the average person appears to have decided global warming is a problem by sheer dint of media reporting on the issue.

Developing a deeper understanding of how the climate system operates, of how human activities can influence that system, and of what uncertainties remain in trying to predict future environmental conditions is crucial for the public to be able to engage in policy debates and make informed decisions at the voting booth. For this reason, this proposal is very meritorious and worthy of support. The PIs do a good job of explaining the cognitive importance of analogy development and make the point that learning by analogy can be taught as a skill that improves with practice. They have extensively documented the cognitive aspects of the proposal, so it is quite clear that they are well versed in pedagogical theory.

I have to confess to being a little bit lost in some of the educational jargon used in the proposal. Some concrete examples of how the experimental and control groups might work through a particular concept/body of knowledge would be helpful in order to allow me to evaluate the differences in instruction the two groups will receive. I'm also not entirely sure I follow the purpose of the SPSS analysis of students' text in exercises. The PIs note that the text analysis is supposed to illuminate student misconceptions, but I'm not sure how looking at a word or phrase does this. Again, a couple of concrete examples would be helpful. Examples of how the evaluation of whether students are using warrants and backings will be carried out would also be useful.

What are the broader impacts of the proposed activity?

If the PIs are successful in developing a number of analogies that can be used to foster better understanding of global warming and climate change, they will have made a significant contribution to the planet. They are teaching very large general education courses, and their analogies are likely to work with students in this kind of setting across the country. Indeed, the PIs intend to use demographic data in conjunction with the

concept quizzes they administer to students to determine whether specific analogies work across ethnic, racial, class, and gender lines, or whether they target particular groups more than others. This kind of research may allow for the development of multiple analogies to explain a single phenomenon, thereby reaching the widest possible audience. Given the importance of an educated population on this particular issue and the potential of this research to lead to methods that may be broadly applicable across the country, this strikes me as work that should be funded.

Summary Statement

This proposal has the capability to advance climate change education, and as such is very worthy of support.

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Organization: Michigan State University

Review #2

Proposal Number: 0941492
Performing Organization: Michigan State University
NSF Program: CCLI-Type 1 (Exploratory)
Principal Investigator: Sibley, Duncan
Proposal Title: Collaborative Research: Building Global Climate Change Literacy through Analogical Reasoning
Rating: Very Good

REVIEW:

What is the intellectual merit of the proposed activity?

An analogical reasoning approach to teaching climate is innovative and potentially transformative. Scientists use analogies to develop research ideas as well as for instruction of well-known concepts. Therefore, the implementation of effective analogical teaching would be beneficial for science majors and non-majors. The team has sufficient expertise to carry out the project and the ideas and workplan are well-conceived. One shortcoming is that the introduction of "bad" analogies leading students is not addressed in the assesment/evaluation narrative. That is, how will the team evaluate whether or not students develop poor analogies, which lead to poor conceptualization? Furthermore, how can this be avoided when teaching students how to develop effective analogies themselves?

What are the broader impacts of the proposed activity?

The impact is certainly broad since, if effective, teaching by analogy could transform how geoscience is taught in general, at all levels (K-16, even graduate/post-graduate. One shortcoming of the concept is that the use of analogies in complex system (such as climate) seems to require more content knowledge, and therefore may not be as applicable as it is in understanding simpler systems (such as one component of the climate system, e.g. condensation).

Summary Statement

The proposed activity is well conceived and supported by significant expertise in pedagogy and content material. Teaching by analogy could potentially be very effective at all levels of geoscience education and materials (analogies) produced by this effort would be extremely useful to the wider community.

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Organization: Michigan State University

Review #1

Proposal Number: 0941492
Performing Organization: Michigan State University
NSF Program: CCLI-Type 1 (Exploratory)
Principal Investigator: Sibley, Duncan
Proposal Title: Collaborative Research: Building Global Climate Change Literacy through Analogical Reasoning
Rating: Good

REVIEW:

What is the intellectual merit of the proposed activity?

Major strengths of this proposal are its concept and the expertise of the proposers. The authors present clearly stated reasoning for creating new instructional/learning materials and strategies that foster student ability to use analogies to make and evaluate claims about global climate, and put forth a hypothesis that non-science majors' climate change literacy can be greatly improved using their materials and methods. The investigators have an extensive background and knowledge of analogical reasoning and cognitive science which is a necessity for this project.

The project description contains some good explanations and examples of the 'problem' of the public's awareness vs. scientific understanding of global climate change processes. The authors provide focused objectives and a plan. The results of some preliminary work by the P.I. are presented and demonstrate that the authors have put some thought into strengthening and refining the use of analogical reasoning in science instruction.

Some figures are clear and useful. Table 4 is a useful visual comparing activities performed by the experimental vs. control (or comparison?) group. The work plan and evaluation design are well organized but quite ambitious.

A computer-related/technological aspect of this proposed work is the use of SPSS Text Analysis Survey to facilitate analyses of text such as interview responses or journals, which is an interesting approach, and though not foolproof, is a useful, underutilized tool.

The weaknesses of the proposal's merit are feasibility and focus in execution. The project's hypothesis that non-science majors' climate change literacy can be greatly improved using their materials and methods will require all due diligence to test objectively and unambiguously.

The proposal could benefit from a discussion of how easy this approach will be for teachers and students to use: specifically, how much training will faculty need? And what level of content knowledge is required of students? Looking at the activities listed in Table 4, I wonder if some are realistic for a general ed non-science population.

What are the broader impacts of the proposed activity?

If the instructional materials will improve general education students' reasoning on global climate change, then this could provide a broader impact. The assertion that their materials will also be useful for K-12

teachers and educators in informal settings is questionable at this stage. Results will be presented at GSA and NARST, and published in relevant education journals. Materials will be submitted to FLAG, DLESE, and GCI.

The investigators also state that the materials will also be useful for K-12 teachers and educators in informal settings. Will the instructional materials be sufficiently user-friendly? I can imagine some teachers lacking confidence or skills needed to guide the learning process. It would have helped if the authors had addressed this issue in some depth.

Summary Statement

The proposed concept and reasoning behind it are interesting, innovative and potentially transformative. Though the authors have defined objectives and a plan, the perceived complexity of this method to teach content is a concern that the authors might address. The authors have not explained what level of prerequisite content is needed by students for successful outcomes, nor what level of content and training teachers outside their team would need to use their method and materials.

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Organization: Michigan State University

Panel Summary #1

Proposal Number: 0941492

Panel Summary:

Panel Summary

INTELLECTUAL MERIT:

- The approach proposed, using analogy-based instruction & the development of analogy-based curricula on climate change as a means to demonstrate scientific reasoning is innovative and built upon previous science education research.
- The proposal meets the criteria for Intellectual Merit and has the potential to advance our knowledge of STEM education
- The researchers are considered highly qualified and in essence specialized to implement this study of analogical reasoning and to produce/analyze the results in a meaningful way.
- In the context of the CCLI program this project requires a relatively modest amount of funding with the potential for transformative results.

BROADER IMPACTS:

- The panel is in general agreement that the project is transformative, novel, and innovative with the potential for broader impacts on STEM education.
- The research results have the potential to help advance our understanding of "how students learn".
- The panel sees extreme value in scaling the proposal to the development of the analogical exercises and data, determining the extent to which they are useful, the extent of their limitation, and the extent to which they can disseminate the information more broadly. At that point the panel would encourage the researchers to request further support that focuses on implementation in undergraduate curricula and broader dissemination.

SUGGESTIONS:

- The panel wishes that the researchers address some of the possible uncertainties that may result from the project plan. Specifically the proposal suggests the use of a comparison group to test the efficacy of analogical reasoning on the comprehension of complex climate concepts. From the panel discussion the implementation of an analogy-centered curriculum in an entire undergraduate course seems premature and the knowledge gained may be confounded by complicating factors such as cross-talking among students from different sections. The panel suggested the idea of a pilot study in which students would be selected to create an external control group to test the pedagogy of analogical reasoning. The outcomes and activities produced could then be utilized in a separate grant that addresses broad dissemination of analogical reasoning in the undergraduate curriculum.

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